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INSTITUTE FOR DEFENSE ANALYSES

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June 2014

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WEAI

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IDA | Background

- Commission established January 2013
- Impetus: Congressional skepticism of Active/Reserve choices made by Air Force (AF)
 - Goal: Undertake a comprehensive study of AF structure to determine force structure modifications to fulfill missions with available resources
- Some considerations
 - Achieve appropriate balance among Components
 - Maintain rotation of 1:2 for Active and 1:5 for Reserve
- Report due (and delivered) by February 1, 2014
- We started work in mid-November – combination of using existing tools and building simple new ones

IDA | Tasking: Address Four Questions

- What are the feasibility and cost implications of maintaining desired Air Reserve Component (ARC) strength levels with an ARC that is expected to be voluntarily activated one-sixth of the time?
- What are the cost implications of having a more Reserve-intensive F-16 force?
- What are the cost and availability implications of placing more Security Force assets in the ARC?
- What are the cost implications of using more ARC pilots to provide initial pilot training?

IDA | Maintaining an ARC Mobilization:Dwell Ratio of 1:5

- Focus: the recruiting and retention consequences
- Drew on Reserve Component Simulation Model (R-SIM) to forecast response to
 - Different activation policies
 - Alternative compensation
 - Previously unoffered contract options
- Estimate preferences based on choices over ten-year period
 - Importance of compensation
 - Willingness to serve
 - Apply preferences to predict responses to hypothetical situations
- Aspects of analysis
 - Novel model accounts for attitudes of RC members' attitudes towards and experience of active duty
 - Period of observation includes both peacetime and extended conflict
 - Modeled each Reserve Component separately

- R-SIM was estimated using data on activations in support of named contingencies
- During the height of Operation Enduring Freedom/Operation Iraqi Freedom (OEF/OIF), these data indicated a rotation rate of about 1:9
- Some active duty is not captured in these data (not served in official support of a contingency)
- We examined two interpretations of the motivating question
 1. Sustaining wartime active duty rates (R-SIM 1:9) indefinitely (this implicitly includes ALL active duty served in OEF/OIF)
 2. Sustaining R-SIM 1:5 (may correspond to true rates that are actually in excess of 1:5)

IDA | Results for Prior Service Recruits

	Accessions	Strength	Available
R-SIM Baseline (OE&F/OIF)	100%	100%	100%
1:9 Indefinitely	72%	92%	92%
1:5 Indefinitely	64%	109%	181%
1:9 with \$10K/yr extra	105%	115%	115%
1:5 with \$10K/yr extra	75%	120%	200%

- Higher rotation rates reduce accessions
- However, they induce high retention among those with a higher “taste for service”
- Consequently, total strength is not greatly affected
- Increasing the rotation rate increases the fraction of the force that is available at any given time

IDA | Implications of Tailoring Contracts to Tastes

	Accessions	Strength	Available
R-SIM Baseline (OEF/OIF)	100%	100%	100%
Contract Choice 1:10 or 1:8	72%	95%	104%
Contract Choice 1:6 or 1:4	64%	116%	223%

- Offering alternative contracts with a “high” and “low” rotation commitment option
 1. Allows recruits to select their preferred level of tempo
 2. Increases the available force because many self-select for higher tempo

IDA | Cost Implications of a More RC-Intensive F-16 Force

- Uses IDA's Total Force Cost Methodology for the AF
 - Most cost factors from AF sources
 - Inputs include force size, mix, and BOG-to-Dwell ratio for AC, MOB-to-Dwell for RC
 - Outputs are annual cost for the force and potential deployment capability
- Some characteristics of analysis
 - Training at normal historical rates, with some excursions
 - AC and AF Reserve squadrons have 24 aircraft, Air National Guard (ANG) have 21
 - Deployments of 120 days with adjustment for more rapid pilot rotation
 - BOG-to Dwell of 1:2, 1:3; MOB-to-Dwell of 1:5, 1:7

IDA | Squadron Annual Costs

	ACC	USAFE	PACAF	AFR	ANG
Primary Aircraft Authorization (PAA)	24	24	24	24	21
Flying Hours/PAA/Year	312	336	280	233	180
Cost Element (\$M)					
Unit-Level Personnel	53.1	73.8	76.8	52.2	35.9
Unit Operations	35.6	38.4	32	26.6	18.0
Maintenance and Support	76.7	98.7	88.8	46.9	58.3
Continuing System Improvements*	9.4	9.4	9.4	9.4	8.2
Total	177.8	220.4	207.0	135.2	120.4
Cost/PAA/Year (\$M)	7.41	9.18	8.63	5.63	5.74

* Allocated on basis of fraction of procurement cost and number of aircraft

- ARC is about 20% cheaper than Air Combat Command
- AF Reserve and ANG similar: Guard flies less but has higher support costs

IDA | Results of Exploratory F-16 Analysis

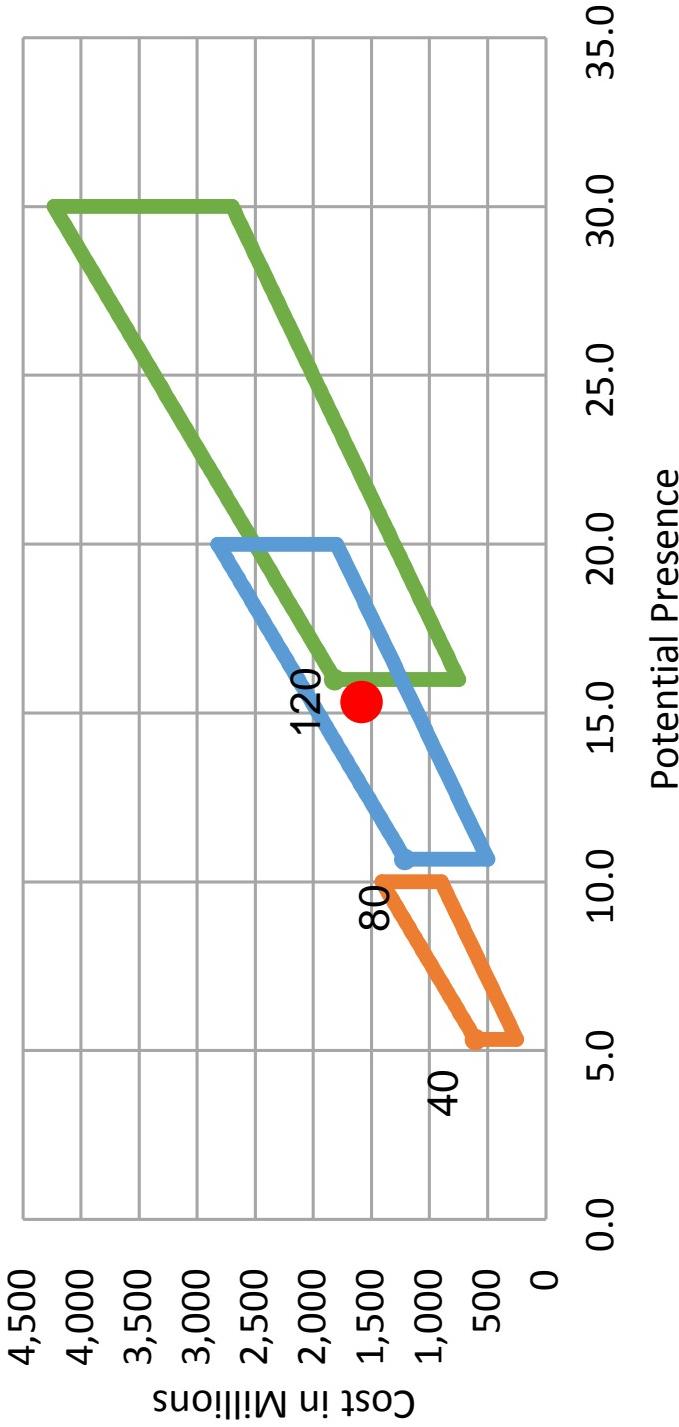
BOG-to-Dwell 1:2, MOB-to-Dwell 1:5							
		Baseline			Shift to RC		
	AC	RC	Total	AC	RC	Total	Tiered RC Readiness
Rotating	175	300	475	143	360	503	360
Forward Stationed	50	0	50	32	0	32	0
Total PAA	225	300	525	175	360	535	360
Annual Cost (\$M)	2,323	2,213	4,536	1,804	2,656	4,459	2,351
Rotationally Deployed			108			108	108

- A shift to the RC and reduced forward stationing can yield same rotational capability and slightly increase force size at similar cost
- Reducing RC readiness until period before planned deployment could save money

IDA | Placing More Security Assets in the ARC

- Data on Air Force unit operating costs only cover flying units
 - We used Army model: Army MP battalion (170 people) stood in for Air Force Base Defense Squadron (200 people)
- Assumed greater use of ARC consistent with CONUS mission
- Question: What are the cost implications of providing rotationally deployed presence with alternative AC-RC mixes?
- Examined various BOG-to-Dwell and MOB-to-Dwell ratios
- Varied percentage of time available units would deploy

Cost and BOG Generation at 1:3/1:5				
	Active		National Guard	
	Annual Cost Per Airman (\$K)	Available BOG/unit	BOG/unit	Annual Cost Per Airman (\$K)
Available Units Do Not Deploy	132	0.25	0.00	37
Available Units Deploy	207	0.25	0.25	89
				0.13
				0.00
				0.13



- Three force sizes illustrated: 40, 80, and 120 battalions
- Reserve-intensive force structures can provide presence less expensively even with more units
- CONUS requirements are not considered in this analysis

IDA | Using More ARC Instructors to Provide Initial Pilot Training

- Most initial pilot training is provided by AC instructors
 - Many are fighter pilots
 - Every active instructor is one more active pilot in the force who must be trained
 - Additional ARC instructors are already trained
- Training fighter pilots is **very expensive**
 - \$3.6 million for initial qualification
 - \$2.7 million for requalification after filling non-fighter billets
- RC instructors could provide initial training on a rotating basis
 - Already fully trained
 - No need for requalification training after assignment

Assumptions

- Additional trained pilots can be attracted to the ARC
- Active fighter pilot turnover rate is 10%; \$360K initial training cost per year
- All AC instructors return to flying billets and must be retrained after 3 years; \$900K retraining cost per year
- ARC instructors fly 60 days/year, AC instructors fly 200; each spends 2 days solely maintaining proficiency
- ARC pilots cost \$13K more than AC pilots per billet filled

Findings

- Net savings per billet converted $\approx \$1.4M$ per year

- We largely used existing tools to quickly address issues raised by the Commission on the Structure of the Air Force
 - Demonstrates the value of building institutional capability
- We found that
 - A 1:5 Mobilization:Dwell ratio appears feasible for the ARC
 - A more RC-intensive F-16 force can generate rotational capability and make a slightly larger force structure affordable
 - A more RC-intensive Security Force has similar characteristics, but even more so
 - The use of ARC instructor pilots can yield savings
- The Commission cited our pilot training findings and the Air Force has shown interest

BACK-UPS

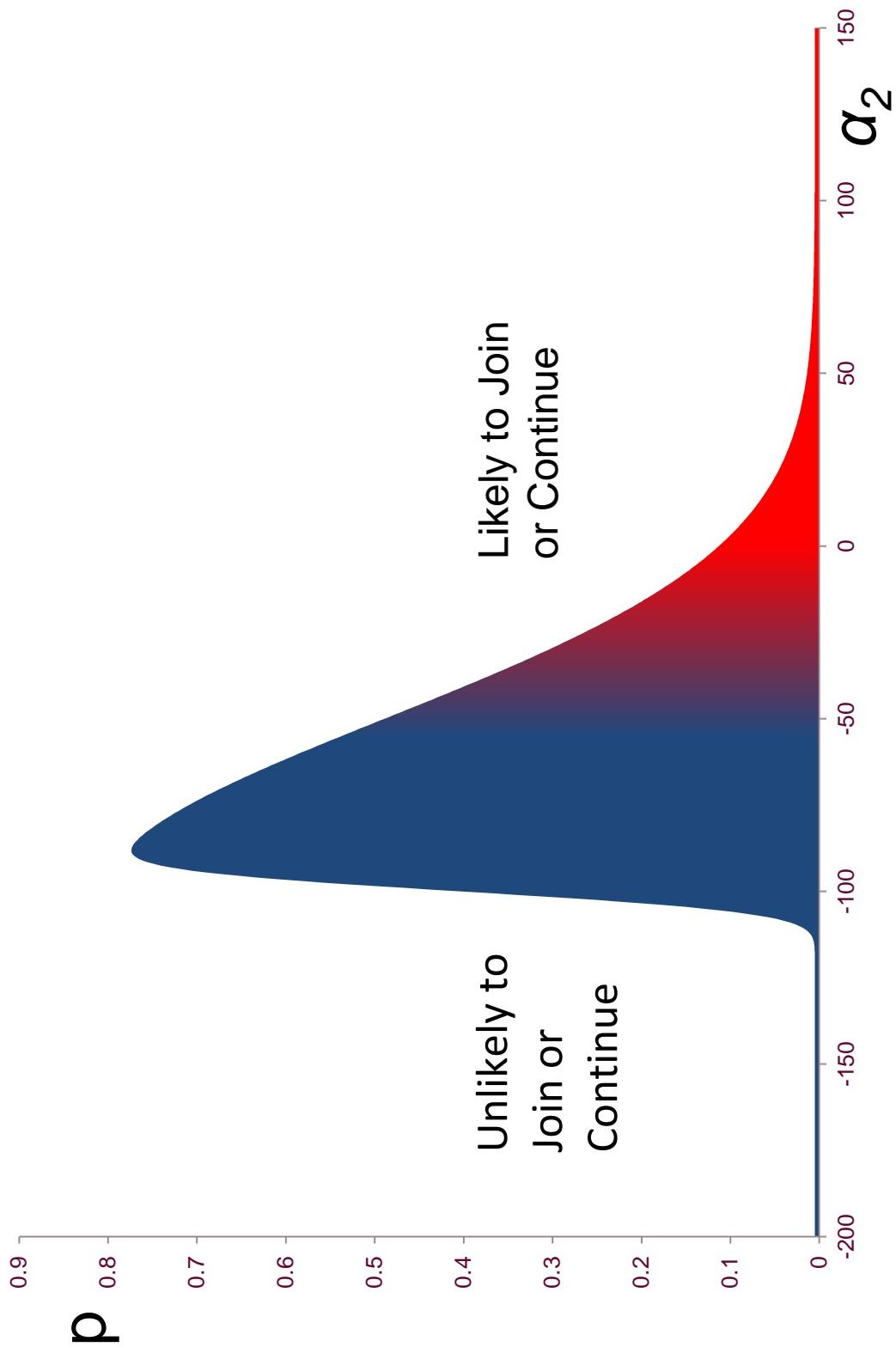
- R-SIM Inputs
 - Military eligible population
 - Peace/war transition probabilities
 - Dwell times (by war state)
 - Active duty lengths (by war state)
 - Military and civilian income at each year of service
 - Youth unemployment rate (age 18–24)
 - Casualties (land components only)
- R-SIM predicts strengths for different policies and situations
 - Number of enlisted accessions by Fiscal Year (FY)
 - Enlisted end strength by year of service and FY
 - Enlisted continuation rates by year of service and FY

IDA | The R-SIM Model

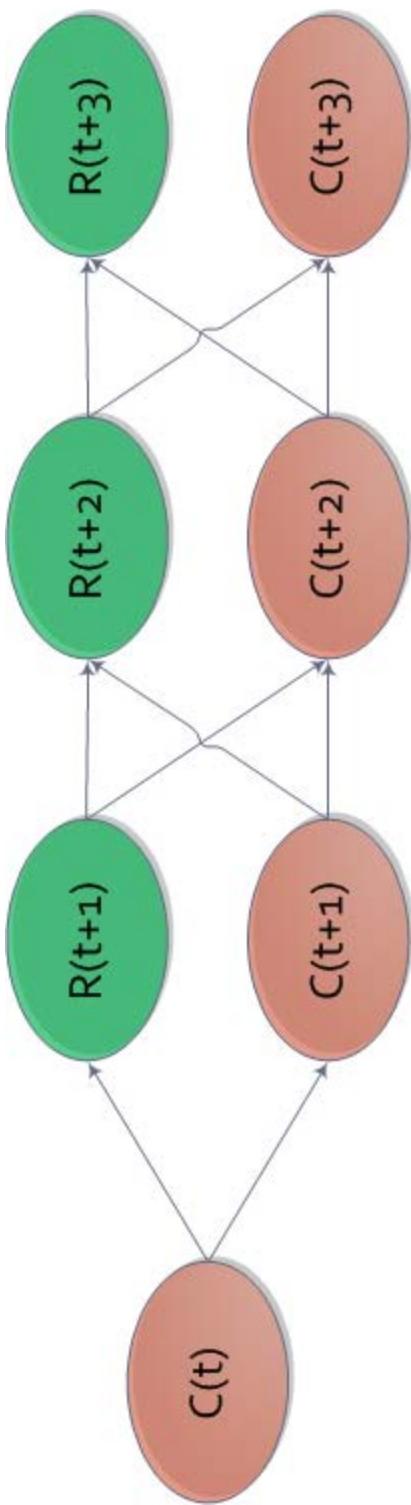
- Young civilians decide in each year whether to join the Selected Reserve
- Reservists and Guardsmen decide in each year whether to stay or leave
- They compare the benefits from leaving in the current year with the benefits from staying until retirement eligibility
- To make this decision, they consider
 - Money income
 - The amount of time that they spend on active duty (past, present, and future)
 - Random events
 - The likelihood of future war
- Each civilian (and Reservist/Guardsman) has a different preference for their ideal amount of active duty
- These preferences are described by a statistical distribution covering the entire population, α_2

- α_2 represents an individual's preference for military service or willingness to serve
- A unique α_2 is drawn from a skew-normal distribution for each individual
- Individuals have either a positive or negative preference for service based on their unique α_2 draw
- α_2 is distributed skew-normal
- Location, scale, and shape parameters determine the shape of the distribution

IDA | Illustrative Distribution

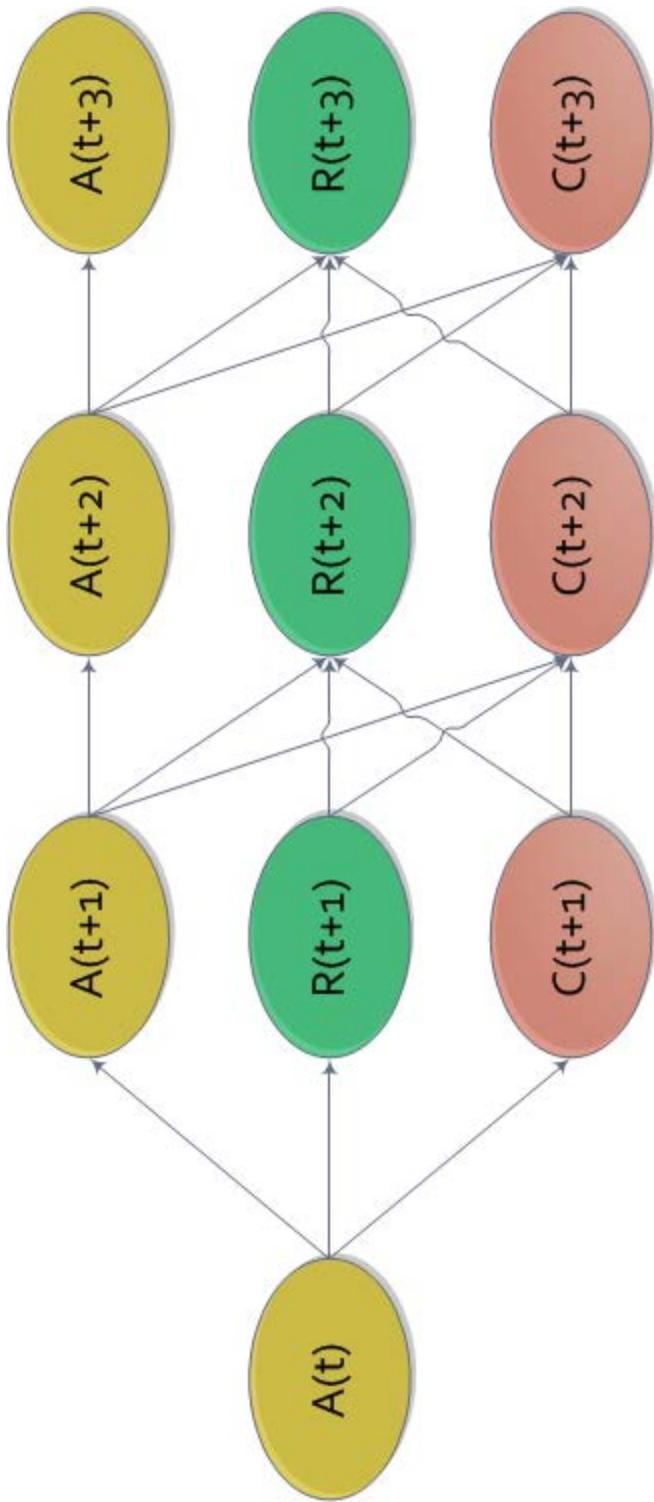


IDA | Non-Prior Service Decision Model



- R = Reserve
- C = civilian
- * Note: an individual can only join the Reserve one time. Once he leaves, he remains in the civilian state.

IDA | Prior Service Decision Model



- A = Active force
- R = Reserve
- C = civilian

* Note: an individual can only join the Reserve one time. Once he leaves, he remains in the civilian state.

IDA | Estimation Method: R-SIM Decisions

- Individuals join/continue if: $Utility > 0$

$$Join_Utility_{t,i} = \alpha_m ACOL_{t,i} + \alpha_{2i} S_{t2} + \alpha_c Casualties_t + \alpha_u Unemployment_{t,i} + \phi_{j_{t,i}}$$

$$Stay_Utility_{t,i} = \alpha_m ACOL_{t,i} + \alpha_{2i} S_{t2} + \phi_{s_{t,i}}$$

- $ACOL$: Annualized money cost of leaving
- α_2 : Preference for service
- S_{t2} : Discounted sum of squared months on active duty
- ϕ : Mean zero shocks
- Based on the Canonical ACOL-2 model of retention:

$$Stay_Utility_{t,i} = ACOL_{t,i} + \alpha_i + \phi$$

- Military/civilian income differential and unique activation schedules determine ACOL
- Match military and civilian earnings using RAND compensation data to determine the income differential
- Use activation schedule to determine time activated for each individual

$$COL_t = (MilActiveEarn_t - CivEarn_t)(Active_t) + \\ MillInactiveEarn_t(1 - Active_t)$$

- ACOL is the present value of all future COLs, expressed as an annualized amount.

- Factors determining individual's unique activation schedule:
 - Peace/war transition probabilities
 - Distribution of dwell times in wartime
 - Distribution of active duty lengths in wartime
 - These distributions are taken from the experience of all serving in the reserve component 2002–2009
- Use activation schedule to determine S_{t2}
 - Compute squared cumulative months on active duty at each month and take the discounted sum

- Data includes 20+ million observations of enlisted Service members from 2000 to 2009
 - All Services
 - Reserve and Guard Components
 - Personnel files (include joining and staying)
 - Activation files (dates of all individual activation and dwell times)
 - RAND earnings file (matches military and civilian earnings of groups of Reservists based on Social Security Administration data)

IDA | Calibration Method

- The calibrated parameters are α_m , α_c , α_u , $\phi_{j_{t,I}}$, $\phi_{s_{t,i}}$ and the location, scale, and shape parameters of the α_2 distribution
- We use the Nelder-Mead polytope optimization method to find the parameters that produce the best match to actual military strength and continuation rate data
 - Many thousands of simulated Service members are randomly drawn from the R-SIM population distribution
 - Each Service member makes joining and staying decisions
 - Minimize square difference between predicted and actual accession/continuation data
- Accession is measured by total number joining per year
- Continuation is measured as the percentage of Service members continuing to the next year of service
- Weigh accession and continuation cells equally
- We calibrate to years 2000–2006

IDA | Optimization Equation: Non-Prior Service

$$\text{Percent_error} = \frac{20}{7} \sum_{t=2000}^{2006} \left(\frac{\text{actual_join}_t - \text{predicted_join}_t}{\text{actual_join}_t} \right)^2 + \sum_{t=2001}^{2006} \left(\frac{\text{actual_contin}_{1,t} - \text{predicted_contin}_{1,t}}{\text{actual_contin}_{1,t}} \right)^2 + \dots + \sum_{t=2005}^{2006} \left(\frac{\text{actual_contin}_{5,t} - \text{predicted_contin}_{5,t}}{\text{actual_contin}_{5,t}} \right)^2$$

$$\text{contin}_{N,t} = \frac{\text{strength in YOSN in year t}}{\text{strength in YOSN - 1 in year t - 1}}$$

IDA | Model Fit

Air Guard Non-Prior Service Fit Example

Actual Join	% Error	YOS1	Actual Continuation	% Error	YOS2	Actual Continuation	% Error	YOS3	Actual Continuation	% Error	YOS4	Actual Continuation	% Error	YOS5	
4904	6.18%	90.74%	3.05%	8.07%	93.10%	5.45%	Continuation	92.05%	-6.89%	92.52%	-2.18%	Continuation	94.13%	0.15%	Continuation
5600	-5.45%	89.14%	-21.06%	-21.06%	-0.69%	-6.91%	-0.48%	92.41%	-0.84%	94.15%	-2.16%	94.43%	0.67%	94.43%	2.47%
4729															1.51%
4052															
3877	5.47%	89.51%	28.41%	28.41%	-5.64%	90.82%	-8.63%	93.66%	-1.59%	94.75%	0.67%	93.71%	3.34%	95.10%	1.51%
3287															
3951	1.27%	90.39%													

Absolute Percent Error

Non-prior Service	Join Fit	Continuation Fit	Overall
Army Guard	30%	6%	18%
Army Reserve	33%	9%	21%
Air Guard	11%	3%	7%
Air Reserve	21%	5%	13%
Marine Corps Reserve	24%	5%	15%
Navy Reserve	36%	8%	22%
Prior Service			
Army	26%	10%	18%
Air	26%	7%	17%

IDA | Optimization Equation: Prior Service

$$\begin{aligned}
 & \text{Percent Error} \\
 &= \sum_{yos=4}^7 \left[\frac{8}{5} \sum_{t=2001}^{2006} \left(\frac{\text{actual}_{join\ yos,t} - \text{predict}_{join\ yos,t}}{\text{actual}_{join\ yos,t}} \right)^2 \right. \\
 &\quad + \sum_{t=2002}^{2006} \left(\frac{\text{actual}_{contin\ yos,yos+1,t} - \text{predict}_{contin\ yos,yos+1,t}}{\text{actual}_{contin\ yos,yos+1,t}} \right)^2 \\
 &\quad + \sum_{t=2003}^{2006} \left(\frac{\text{actual}_{contin\ yos,yos+2,t} - \text{predict}_{contin\ yos,yos+2,t}}{\text{actual}_{contin\ yos,yos+2,t}} \right)^2 \dots \\
 &\quad \left. + \sum_{t=2006}^{2006} \left(\frac{\text{actual}_{contin\ yos,yos+5,t} - \text{predict}_{contin\ yos,yos+5,t}}{\text{actual}_{contin\ yos,yos+5,t}} \right)^2 \right]
 \end{aligned}$$

$contin_{N,N+j,t}$
 $= \frac{strength\ in\ YOS = N + j\ in\ year\ t\ who\ joined\ with\ N\ years\ of\ active\ service}{strength\ in\ YOS = N + j - 1\ in\ year\ t - 1\ who\ joined\ with\ N\ years\ of\ active\ service}$

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Model Fit – Ex. Air, Prior Service (1 of 2)

	Join in YOS4	% Error	YOS5	Actual	YOS6	Actual	YOS7	Actual	YOS8	Actual	YOS9	Actual	YOS10
2001	1260	-2.06%	Continuation	91.95%	2.85%	71.25%	-6.79%	Continuation	% Error	YOS7	Actual	YOS8	Actual
2002	482	47.30%		90.63%	-0.07%	72.41%	14.90%			71.93%	-0.08%	Continuation	% Error
2003	480	38.75%		90.32%	1.07%	89.29%	-8.82%			66.67%	32.34%	87.80%	-10.44%
2004	664	21.54%		94.12%	-3.62%	89.06%	-9.19%			76.00%	16.69%	78.57%	19.72%
2005	884	11.54%		95.79%	-3.33%							83.33%	-3.84%
2006	799	18.40%											

	Join in YOS5	% Error	YOS6	Actual	YOS7	Actual	YOS8	Actual	YOS9	Actual	YOS10	Actual	YOS10
2001	172	33.14%	Continuation	89.84%	3.04%	78.36%	-21.74%	Continuation	% Error	YOS7	Actual	YOS8	Actual
2002	639	-72.46%		84.23%	3.20%	89.41%	-7.16%			84.55%	-19.94%	Continuation	% Error
2003	549	-20.95%		86.67%		81.01%	2.66%			82.92%	8.25%	84.00%	-8.01%
2004	384	-20.31%		86.60%	0.76%	85.74%	-4.77%			86.05%	4.27%	87.71%	7.01%
2005	530	-30.19%										88.41%	-8.52%
2006	379	-47.76%											

IDA | Model Fit – Ex. Air, Prior Service (2 of 2)

	Join in YOS6	% Error	YOS7									
	127	26.77%	Continuation	% Error	Actual	YOS8						
2001	135	-5.93%	88.95%	4.74%	Continuation	% Error	YOS9					
2002	293	-39.25%	87.32%	1.89%	77.12%	-13.56%	Continuation	% Error	YOS10			
2003	342	-20.76%	86.52%	6.49%	84.41%	-3.55%	80.51%	-13.05%	Continuation	Actual	YOS11	
2004	675	2.81%	83.59%	7.71%	78.74%	3.00%	81.95%	6.10%	81.05%	-3.06%	Continuation	% Error
2005	738	-7.18%	91.89%	-2.15%	81.62%	-2.09%	77.27%	14.82%	87.31%	10.24%	89.61%	-2.61%

	Join in YOS7	% Error	YOS8	Actual	% Error	YOS9	Actual	% Error	YOS10	Actual	% Error	YOS11	Actual	% Error	YOS12	Actual	% Continuation	% Error	YOS13	Actual	% Continuation	% Error		
2001	205	5.85%	Continuation	90.55%	3.31%	Actual	90.71%	10.71%	68.70%	-12.51%	Continuation	84.44%	4.10%	88.74%	2.29%	78.95%	3.43%	81.01%	-14.00%	Continuation	87.50%	-13.95%	Continuation	87.50%
2002	112	0.00%	Continuation	84.44%	4.10%	Actual	86.84%	3.44%	82.69%	2.48%	88.89%	2.48%	82.69%	3.44%	88.89%	2.48%	82.69%	3.44%	88.89%	2.48%	82.69%	3.44%	88.89%	2.48%
2003	130	0.00%	Continuation	84.44%	4.10%	Actual	88.59%	-0.84%	80.47%	0.82%	79.53%	0.82%	88.59%	-0.84%	80.47%	0.82%	79.53%	0.82%	90.00%	10.64%	90.00%	3.80%	87.50%	-12.50%
2004	208	-43.27%	Continuation	88.74%	2.29%	Actual	86.13%	-44.13%	82.13%	-3.93%	88.89%	-3.93%	86.13%	-44.13%	82.13%	-3.93%	88.89%	-3.93%	82.13%	-3.93%	86.13%	-44.13%	82.13%	-3.93%
2005	383	-44.13%	Continuation	86.84%	3.44%	Actual	88.59%	-51.57%	82.57%	-3.93%	88.89%	-3.93%	88.59%	-51.57%	82.57%	-3.93%	88.89%	-3.93%	82.57%	-3.93%	88.59%	-51.57%	82.57%	-3.93%
2006	351	-51.57%	Continuation	88.59%	-0.84%	Actual	80.47%	0.82%	79.53%	0.82%	87.50%	0.82%	80.47%	0.82%	79.53%	0.82%	87.50%	0.82%	80.47%	0.82%	87.50%	0.82%	80.47%	0.82%

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